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# **INTEGRATED BATTLEFIELD EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER**

## **Appendix F—Technical and Operational Impacts of Field Simulators on the National Training Center**

Science Applications International Corporation  
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Technical Report

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## 19. ABSTRACT (Continued)

Demonstration of the system for combining live and notional battalions for training higher level staffs in integrated battlefield (IB) command and control:

Functional requirements analysis for IB command and control simulation      Appendix D  
Report on the demonstration      Appendix E

Analysis and design of field simulators for nuclear and chemical warfare:

Technical and operational impacts of field simulators      Appendix F  
Capability of off-the-shelf paging system to communicate at Ft. Irwin      Appendix G  
Designs of field simulators      Appendix H

Adaptation of nuclear and chemical software to other Army training models:

Feasibility of transferring ARTBASS Code from Perkin-Elmer to VAX      Appendix I  
Division/Corps training simulation functional analysis      Appendix J  
ARTBASS conversion to VAX      Appendix K  
Requirements specification for adding nuclear and chemical models  
to ARTBASS      Appendix L

This research provided the following products:

Software which models nuclear and chemical environment and effects with appropriate fidelity and timing for training and which is ready for installation on NTC computers.

A demonstrated capability for combining actions of real battalions with computer simulated notional battalions for training brigade/division commanders and staffs.

An analysis of the impacts of using field simulators at the NTC for nuclear and chemical warfare training, and the designs of the selected simulators (i.e., common control system, radiacmeters, dosimeters, chemical detectors).

Analysis of the application of nuclear and chemical models to other Army battalion training models; conversion of the ARTBASS model to operate on the VAX 11/730; incorporation of the nuclear and chemical models into ARTBASS; and demonstration of the nuclear and chemical models using ARTBASS.

## SUMMARY

The purpose of this research is to analyze the operability of the concept of using field simulators as part of the enhancement of the National Training Center (NTC) integrated battlefield (IB) training. Field simulators to be analyzed were identified in previous research. They are a radiometer simulator, a dosimeter simulator, a chemical detector/alarm simulator, a masking timer/casualty indicator, an EMP simulator for use with vehicular radios, and a remotely operated chemical simulant sprayer for vehicles. The report first provides estimates quantities of field simulators, costs and other resources required. Next it identifies interfaces of field simulators with other NTC components, and provides an assessment of the compatibility of the interfaces. The report then identifies and analyzes technical and operational issues related to field simulator operation.

Conclusion and recommendations include a phasing concept to reduce near time costs, provide a learning process, and reduce risk. Further RF analysis and testing is recommended.

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## PREFACE

This report is an update of the draft report dated 1 February 1984. The updates are primarily revised estimates of costs of equipment and numbers of transmission sites based on the successful tests of an off-the-shelf commercial transmitter and off-the-shelf commercial pagers to be used as receiver/decoders in the field simulators. The tests were conducted at Fort Irwin on 17 through 20 September 1984.

To assist planners who may have used quantity and cost data from the draft volume, changes in estimates have been marked with a black vertical change bar in the right hand margin.

This report documents research done in compliance with Task 12.1 Statement of Work for Integrated Battlefield Effects Research for the National Training Center. This portion of the Statement of Work is as follows:

### TASK 12.1 Identification and Analysis of Technical and Operational Considerations

Perform all work needed to identify and analyze technical and operational issues associated with integrating IB field simulators into the NTC field instrumentation and using these simulators in training exercises. Specifically, perform the following subtasks:

- Identify interfaces of simulators with each other and with the NTC Core Instrumentation Subsystem (CIS), Range Data Measurement Subsystem (RDMS), Range Monitor and Control Subsystem (RMCS), and with operational and control communications. Analyze the compatibility of these interfaces, identify potential problems, and recommend changes to simulators or to current NTC field instrumentation to assure interface compatibility,
- Estimate the number of simulators of each type required for operation of the NTC, including spares, replacements, and/or maintenance float. Determine requirements for maintenance and logistic support and estimate resources needed for operations and maintenance,
- Address technical and operational issues associated with introducing and operating the proposed field simulators. Technical issues shall include commonality between simulator types, range limitations, area coverage, probability of false alarms and errors. Operational issues will include

- requirements for issuing and initializing simulators, monitoring simulator operability and loads, limitations on training scenarios, and effects of simulator failures or errors on training credibility, and
- Document results and recommend changes to simulator design concepts based on the results of the foregoing technical and operational analyses.

# CONVERSION FACTORS FOR U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

To Convert From	To	Multiply By
angstrom	Meters (m)	1.000 000 x E -10
atmosphere (normal)	Kilo pascal (kPa)	1.013 25 X E +2
bar	kilo pascal (kPa)	1.000 000 X E +2
barn	meter <sup>2</sup> (m <sup>2</sup> )	1.000 000 X E -28
British thermal unit (thermochemical)	joule (J)	1.054 350 X E +3
cal (thermochemical)/cm <sup>2</sup>	mega joule/m <sup>2</sup> (MJ/m <sup>2</sup> )	4.184 000 X E -2
calorie (thermochemical)	joule (J)	4.184 000
calorie (thermochemical)/g	joule per kilogram (J/kg)*	4.184 000 X E +3
curie	giga becquerel (Gbq) +	3.700 000 X E +1
degree Celsius	degree kelvin (K)	$T_K = T_C + 273.15$
degree (angle)	radian (rad)	1.745 329 X E -2
degree Fahrenheit	degree kelvin (K)	$T_K = (T_F + 459.67)/1.8$
electron volt	joule (J)	1.602 19 X E -19
erg	joule (J)	1.000 000 X E -7
erg/second	watt (W)	1.000 000 X E -7
foot	meter (m)	3.048 000 X E -1
foot-pound-force	joule (J)	1.355 818
gallon (U.S. liquid)	meter <sup>3</sup> (m <sup>3</sup> )	3.785 412 X E -3
inch	meter (m)	2.540 000 X E -2
jerk	joule (J)	1.000 000 X E +9
joule kilogram (J/kg) (radiation dose absorbed)	gray (Gy)*	1.000 000
kilotons	terajoules	4.183
kip (1000 lbf)	newton (N)	4.448 222 X E +3
kip/inch <sup>2</sup> (ksi)	kilo pascal (kPa)	6.894 757 X E +3
ktop	newton-second/m <sup>2</sup> (N-s/m <sup>2</sup> )	1.000 000 X E +2
micron	meter (m)	1.000 000 X E -6
mil	meter (m)	2.540 000 X E -5
mile (international)	meter (m)	1.609 344 X E +3
ounce	kilogram (kg)	2.834 952 X E -2
pound-force (lbf avoirdupois)	newton (N)	4.448 222
pound-force inch	newton-meter (N-m)	1.129 848 X E -1
pound-force/inch	newton/meter (N/m)	1.751 268 X E +2
pound-force/foot <sup>2</sup>	kilo pascal (kPa)	4.788 026 X E -2
pound-force/inch <sup>2</sup> (psi)	kilo pascal (kPa)	6.894 757
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 X E -1
pound-mass-foot <sup>2</sup> (moment of inertia)	kilogram-meter <sup>2</sup> (kg-m <sup>2</sup> )	4.214 011 X E -2
pound-mass/foot <sup>3</sup>	kilogram-meter <sup>3</sup> (kg/m <sup>3</sup> )	1.601 846 X E +1
rad (radiation dose absorbed)	gray (Gy)*	1.000 000 X E -2
roentgen	coulomb/kilogram (C/kg)	2.579 760 X E -4
shake	second (s)	1.000 000 X E -8
slug	kilogram (kg)	1.459 390 X E -1
torr (mm Hg, 0° C)	kilo pascal (kPa)	1.333 22 X E -1

\*The gray (Gy) is the accepted SI unit equivalent to the energy imparted by ionizing radiation to a mass and corresponds to one joule/kilogram.

The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.

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## SECTION 1 INTRODUCTION

### 1.1 Purpose and Scope

The purpose of this research was to examine the operability of the concept of using field simulators as part of the enhancement of the National Training Center (NTC) integrated battlefield (IB) training. (IB training in this case consists of tactical nuclear and chemical warfare.) The following aspects of operability were considered:

1. Resources required: elements of the field simulator system, quantities of each type simulator, operational and logistic support, and costs.
2. Interface identification and compatability to include interfaces between field simulators and other subsystems and between different field simulators.
3. Identification and analysis of technical issues relating to use of field simulators.
4. Identification and analysis of operational issues relating to use of field simulators.

The analysis of each of these aspects of the operability is documented in this report, followed by overall conclusions and recommendations.

### 1.2 Organization Within the NTC System

The organizational approach to integrating the field simulators into the NTC includes the new hardware and software as a component of the Core Instrumentation Subsystem (CIS) of the NTC. This maintains organizational simplicity since the simulators are being developed by the contractor responsible for the CIS. However, the fundamental interface requirements, the technical and operational impact on NTC operations, and the design and use of the simulators are independent of organizational approach. The findings of this research are independent of where the field simulators are placed in the NTC system organization chart.

Throughout this report the nomenclature for system hierarchy corresponds to that in other NTC documentation, i.e:

Level -----	Name -----
1	System
2	Subsystem
3	Component
4	Module
5	Element

The NTC system consists of several subsystems; each subsystem consists of several components; and each component may consist of several modules: The Core Instrumentation Subsystem (CIS) is part of the NTC system. The Nuclear/Chemical Field Simulator Component (N/C FSC) is part of the CIS. The N/C FSC consists of three modules. These modules contain several elements.

### 1.3 Concept for Employment of Nuclear/Chemical Field Simulators

This brief description of the concept provides a frame of reference for the following analysis of the technical and operational impact on the NTC of nuclear/chemical field simulators. More detailed information is provided in the following reports:

"Integrated Battlefield Research for National Training Center, Volume 1, Executive Summary" Science Applications, Incorporated, August 1983 (Draft)

"Integrated Battlefield Research for the National Training Center, Volume 4, Field Simulators, Science Applications, Incorporated, 30 June 1983 (Draft).

In the overall concept (Figure 1) the simulated nuclear and chemical environments, and their effects on personnel and equipment, are computed and stored in the Computational Component (CC) of the Core Instrumentation Subsystem (CIS). The simulated radiation rate and chemical environment is computed throughout the exercise areas at least every two minutes. In addition, accumulated dose levels, contamination and degradation of players and platoon sized units are available computed and stored in the CC.

The CC also stores the correlation of units with field simulators and the field simulators address codes. Nuclear

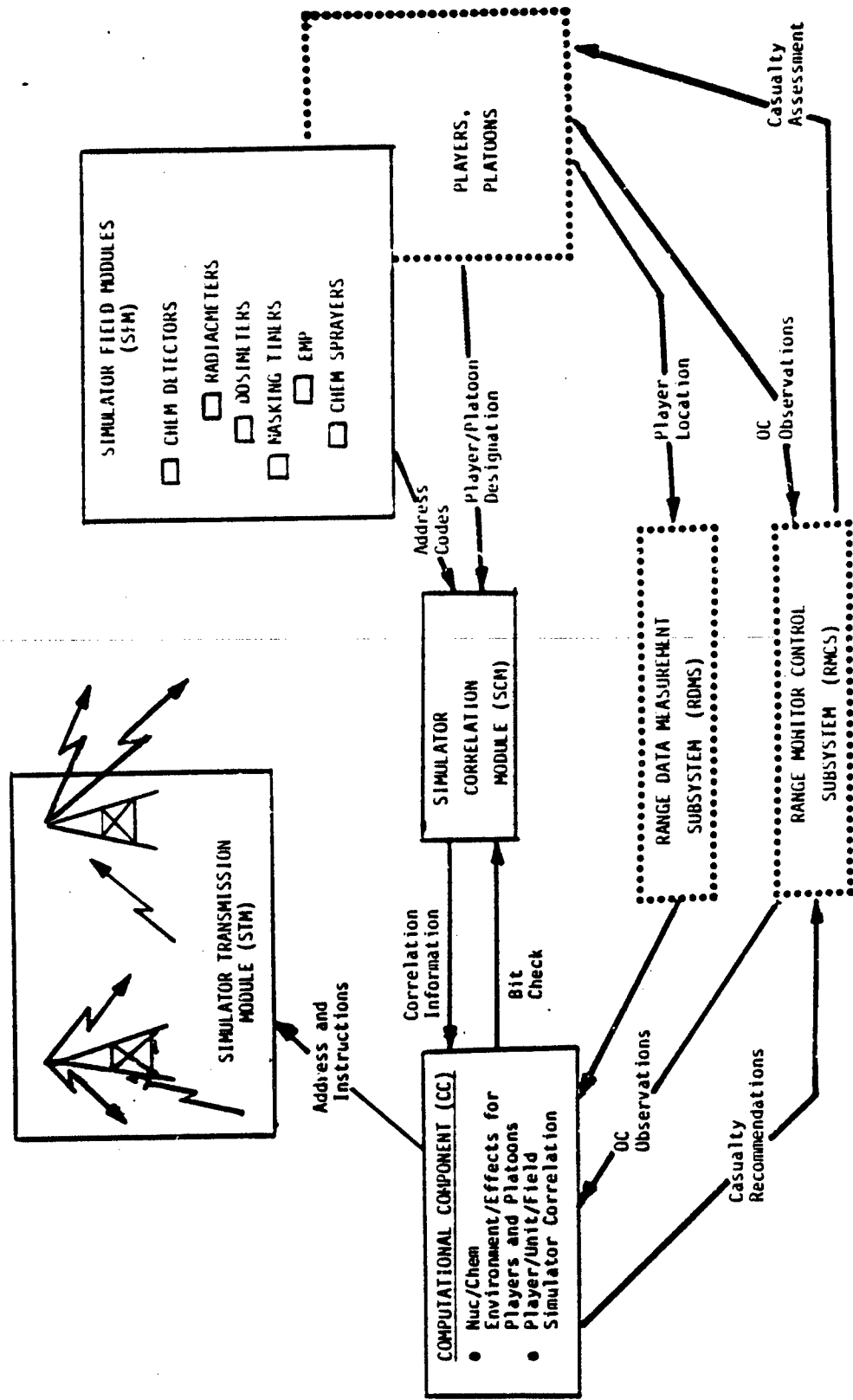


Figure 1. Concept for nuclear/chemical field simulator component.

and chemical environments and effects information is filtered to identify that information which relates to units having field simulators. These units' designations are then linked with the address codes of the field simulators for each unit, and the field simulator control messages are formatted to describe environment or effects. Each message, consisting of a field simulator address and instructions, is passed from the CC to the Simulator Transmission Module (STM).

The STM consists of a cable or Rf link to good relay locations, (e.g., Tiefert Mountain and Granite Mountain) and from there via an omnidirectional link to all simulators within the maneuver areas. The STM link is one-way from CIS Computational Component (CC) to the Simulator Field Modules (SFM). Each message is sequentially sent to each of the relay stations to provide the best transmission to the field simulators for all locations.

Based on previous research, the following six types of SFMs were considered:

- Radiacmeter
- Dosimeter
- Chemical Alarm
- Masking Timer/Casualty Indicator
- EMP Radio Interrupter
- Chemical Contaminant Simulant Sprayer

These simulators have been selected to provide realistic cues for environments and effects to satisfy current Army training objectives. The messages received via the STM cause the SFMs to indicate the following environment and effects which have been computed and stored in the CC and updated at least every two minutes:

- Radiation rate at the location of the unit to which the radiacmeter simulator is assigned.
- Total radiation accumulated dose (since the dosimeter was last zeroed) for the unit to which the dosimeter simulator is assigned.
- Activation of the alarm signal at the chemical agent detector if the detector is in an area of chemical contamination.

- A kill signal for all members of each platoon which is in an area of chemical lethal concentration. A transducer on the mask provides a signal which interrupts the kill signal when the mask is worn.
- Disablement of radios which are operating within the area in which EMP would disable radios. The disablement can be reversed by a field controller.
- Release of a chemical simulant spray on tanks and APCs.

Correlation of unit/player identification and SFM address codes is accomplished by field controllers before exercises begin. Initially this will be done manually, as is currently done with "B" units. As the higher quantity type simulators become operational this will be done using the Simulator Correlation Module (SCM). The SCM consists of a bar code reader, a keyboard input, a data storage device, and an RF transmitter/receiver. For each company-sized unit, a field controller enters the unit designation via the keyboard or bar codes. He then scans the type and address code of each field simulator assigned to the unit by use of the bar code reader. (Each field simulator has a bar code attached). After the information is collected, it is transmitted to the CIS, via the SCM RF link, and entered into the CC.

Functions which are part of the current system, but which will assist in the nuclear and chemical training are shown with dotted boxes in Figure 1. Player location for instrumented players will be tracked by the RDMS. This will provide the location of field simulators whose collocation with the players has been established using the SCM.

Field controllers will observe players and provide information on their posture (e.g. inside or outside APC's) to the controllers within the CIS. Casualty recommendations for nuclear and chemical effects follow the reverse path, from the CC via CIS controllers to field controllers, who assess the casualties.

## SECTION 2 RESOURCES REQUIRED

Resources required were analyzed in terms of common elements, field simulators, logistic resources, and costs.

### 2.1 Common Modules

Elements of the Simulator Transmission Module (STM) and the Simulator Correlation Module (SCM) interface in common with all types of simulator field modules.

The Simulator Transmission Module will have a transmitter at the CIS, with two relays, one at Mt. Tiefert and one at Granite Mountain. Each of these two sites will have a transponder which will retransmit signals at a common frequency using an omnidirectional antenna. All signals from the CIS will be transmitted twice, alternating in time between Mt. Tiefert and Granite Mountain. Elements of the STM are summarized in Table 1.

Table 1. Common elements in STM.

Item -----	Quantity -----	Basis -----
RF transmitter vicinity of CIS	1	Transmit to two locations from CIS
RF receiver and transmitter	2	One per retransmission station

An alternate configuration of the STM would have a cable which runs from the CIS to Mt. Tiefert. Availability of the necessary circuitry on this cable should be investigated in design of the STM.

A second alternative would include a mobile relay operating in the vicinity of the troops on the ground in each exercise area.

Common elements of the Simulator Correlation Module (SCM) consist of a bar code reader with wand, recorder, and a two-way radio netted with a radio at the CIS. Five sets of this equipment will be provided for each BLUEFOR battalion field controller and one additional set will be provided as a maintenance float and backup. Elements of the SCM are shown in Table 2. The table is based on providing SCM's to two battalion task forces simultaneously. No SCM's are provided OPFOR, since OPFOR has fewer simulators and they

will be assigned to OPFOR units essentially on a permanent basis.

Table 2. Common elements of the SCM.

<u>Item</u> -----	<u>Quantity</u> -----	<u>Basis</u> -----
Bar code reader with wand	11	5 per battalion plus maintenance float
Correlation recorder	12	5 per battalion plus maintenance float
Radio transmitter/ receiver	12	5 per battalion, 1 per CIS, plus maintenance float

## 2.2 Quantities of Simulator Field Modules (SFM)

Estimated quantities of SFMs are shown in Table 3. Quantities are based on two battalion task forces (BTF) concurrently at the NTC plus limited SFMs for the OPFOR. In the case of the OPFOR, field simulators are used to provide appropriate realism by handicapping the OPFOR, when appropriate, by having them wear masks and be subjected to EMP. One BTF is assumed to be in a two-sided engagement simulation (ES) in one corridor; the other BTF is assumed to be in ES in the other corridor or on the live fire (LF) range. Quantities of simulators are based on the forthcoming "J" series of the Tables of Organization and Equipment (TOE), since these TOEs will be in effect when the field simulators are implemented. Quantities of the first four simulators are based on information provided by Army operations personnel at Ft. Irwin. Also included are approximately 10% spare simulators. The exact number of spares varies depends on the type simulator.

Note that of the 3615 field simulators only 490 (radiacmeters and dosimeters) require quantitative type messages. The remaining 3125 are required to output an on-off signal, which can be attained by either addressing or not addressing the simulator.

Table 3. Quantities of simulators required.

TYPE -----	OPERATIONAL QUANTITY -----	TOTAL QUANTITY -----	BASIS OF ISSUE -----
Radiacmeter IM 174	139	150	One per Bluefor Platoon and Spares
Dosimeter IM 93 or IM 185	307	340	Two per Bluefor Platoon and Spares
Chemical Alarm M-8	113	125	Two per Bluefor Company and Spares
Masking Timers/ Casualty Indicators			One per Trainee and OPFOR Personnel and Spares
M 17 Type	1389	1550	
M 25 Type	753	850	
EMP	300	300	One per tank/APC/ BMP/ZSU and Spares
Chemical Sprayer	300	300	One per tank/APC/ BMP/ZSU and Spares

## 2.3 Logistics Requirements

### 2.3.1 Logistics Concept:

The logistics concept includes maintenance and supply. A simplified logistic concept was formulated as a basis for estimating resource requirements. Detailed analysis to define the best logistic concept will be done as part of implementation. It is planned that a maintenance float will be provided, so that simulators may undergo scheduled and unscheduled maintenance while exercises are in progress. When field simulators fail during use they will be immediately replaced, or, in some cases, the system will be allowed to operate in a degraded mode. Maintenance and supply in the field will be provided by the contact technician approach. Spare simulators and batteries will also be carried by field controllers in their vehicles in quantities based on failure experience. They will be exchanged for nonworking simulators or batteries on a one-for-one basis. Scheduled and unscheduled maintenance will be performed by dedicated maintenance personnel working on a continuing basis during exercises. Between exercises the maintenance personnel will perform that periodic maintenance required to ready the simulators for the next rotation. This maintenance will typically include the following:

1. Change batteries.
2. Sterilize masks which are to be reissued.
3. Test simulators before returning them to stocks.
4. Identify and implement repairs which can be done within time constraints between rotations.
5. Where appropriate, tag simulators for scheduled and unscheduled maintenance. Simulators so tagged will not be reissued, but will be withdrawn for maintenance during the next training cycle.

If off-the-shelf commercial pagers are used as a receiver/decoder for field simulators, a low cost service contract can be arranged. For example Motorola pagers could be delivered to a depot in the Los Angeles area with a two day turn around time for repair. Since pager repair is predicted to be infrequent, a service of this type would probably be economical and effective.

#### 2.3.2 Logistics Related Resources

Logistics related resources which have been considered consist of maintenance manpower, repair parts, maintenance float items, and expendables.

Maintenance man-hours estimates are shown in Table 4. Estimates are based on forty weeks per year of operation. The transmitters and receivers in the STM will not require continuous manning. All STM components will be low maintenance types.

Simulator field modules (SFM) will be designed for low maintenance, and where large quantities of a given type are available, the per unit labor hours required will be greatly reduced. In the field, simulators will be exchanged or repaired by a contact maintenance technician. Field controllers will also have on board a small quantity of simulators for direct exchange.

If Motorola off-the-shelf pagers are used in the design, a 5 year parts and labor contract can be purchased for \$40 each. Assuming the same cost for handling and shipping this would equate to about one man-hour per year for this part of the system.

Table 4. Maintenance man-hours.

Item	Basis	Total M/H/ Year
Simulator Transmission Module (STM)	8 hours/week for common transmitter at CIS and two relays (at Tieford and Granite)	320
Simulator Field Modules (SFM)		
Radiacmeter	1/5 man-hour/week for each of 150 devices	1,200
Dosimeter	1/5 man-hour/week for each of 340 devices	2,720
Chemical Alarm	1/5 man-hour/week for each of 125 devices	1,000
Mask Timer/Casualty Indicator	1/5 man-hour/week for each of 2400 devices	19,200
EMP Simulator	1/5 man-hour/week for each of 300 simulators	2,400
Chemical Sprayer	1/2 man-hour/week for each of 300 simulators	6,000
Contact Maintenance	1 man/battalion task force (BTF) 40 weeks/year 40 hours/week for 2 BTF	3,200
Simulator Correlation Module (SCM)	1/2 man-hour/week for 12 sets	240
Total man-hours/year		33,080

For the operation of the entire system the use of a contact maintenance technician supporting each BLUEFOR battalion is included. The technician would be equipped with a four-wheel drive truck, a supply of maintenance parts and replacement field simulators, components, appropriate tools, and test equipment. He would be on call for exchange of simulators or components, particularly at short breaks or lulls in the training exercises. The second contact maintenance technician would not be provided until government fiscal year (GFY) 1987 when the greatest number of field simulators become operational.

Repair parts are estimated on the basis of an annual cost equal to ten percent of procurement costs per year. Specific types and quantities will depend on more specific designs.

The highest volume expendable items identified at this time appears to be batteries. Recent information from a commercial pager supplier indicates that a common AA pen light battery will operate their pagers up to 31 weeks. Additional battery power beyond that to operate receiver/decoders will be required to provide dosimeter readings, activate chemical alarms, and operate masking kill signal receivers and indicators. This requirement is estimated at one battery set for two weeks operation, giving a total requirement of 20 battery sets per simulator in forty weeks of operation, or 132,000 batteries per year.

## 2.4 Estimated Costs

Cost estimates are provided as a decision aid and for long range and mid-range budget planning, but are not adequately defined at this time for contractual significance.

Costs for the system are estimated based on the preliminary design concept and the quantities of simulators which were shown in Table 3. Costs have been broken down into phases starting with the Federal Government fiscal year (GFY) 1985. Effort in GFY 1984 is planned under the current DNA contract. Phases 1, 2, and 3 would correspond to GFY 1985, 1986, and 1987, Table 5.

Phasing is designed to provide low risk items first, to provide first those items with the highest training value per dollar spent. It turns out that this also provides the least cost items first.

### 2.4.1 Summary of Estimated Costs

Estimated development costs, procurement costs, and operating costs are summarized in Tables 6, 7, and 8 respectively. Development costs are for engineering development and test. Advanced development of the equipment

Table 5. Recommended phasing by government  
fiscal year (GFY).

ACTIVITY	GFY 85	GFY 86	GFY 87
Development	Simulator Transmission Module Field Simulators - Radiacmeter - Dosimeter - Chemical Alarm - Part of Masking Timer/ Casualty Indicator Develop- ment Simulator Control Software	Simulators - Remainder of Masking Timer/ Casualty Indicator Development - EMP Simula- tor - Chemical Sprayer Simulator Correlation Module	
Procurement and Opera- tion	Air/Ground Engagement Simulation (AGES) Software	Simulator Transmission Module Simulators - Radiacmeter - Dosimeter - Chemical Alarm Simulator Control Software	Masking Timer/ Casualty Indicator EMP Simulator Chemical Sprayer Simulator Correlation Module

Table 6. Estimated development cost summary  
by government fiscal year (GFY)  
(thousands of dollars).

ITEM	GFY 85	GFY 86	GFY 87	TOTAL
Common Field Simulator Receiver/Transmitter (STM)	30			30
Simulators Correlator (SCM)		70		70
Common Field Simulator Reciever/Decoder	0			0
Simulators Radiacmeter	100			100
Dosimeter	100			100
Chemical Alarm	100			100
Masking Timer/Casualty Indicator	80	150		230
EMP Simulator		70		70
Contamination Sprayer		20		20
Simulator Control SW	135			135
	545	310		855

Table 7. Estimated procurement cost summary  
by government fiscal year (GFY)  
(thousands of dollars).

ITEM	GFY 85	GFY 86	GFY 87	TOTAL
Nuclear/Chemical Software for Air/Ground Engagment Simulaton System (AGES)	291			291
Common Field Simulator Hard- ware		120	159	279
Field Simulators				
Radiacmeter		240		240
Dosimeter		476		476
Chemical Alarm		125		125
Masking Timer/ Casualty Ind.ca- or			3360	3360
EMP Simulator			270	270
Chemical Sprayer			240	240
Field Simulator Control Software		80		80
Totals	291	1141	4029	5461

Table 8. Estimated annual operating cost summary  
by government fiscal year (GFY)  
(thousands of dollars).

ITEM	GFY 85	GFY 86	GFY 87 and beyond
O & M Nuclear/ Chemical Software for Air/Ground Engagement Simu- lation System (AGES)	0	50	50
O & M Field Simulator Control Software		0	50
Simulator O & M Radiacmeter		56	56
Dosimeter		120	120
Chemical Alarm		40	40
Masking Timer/ Casualty Indicator			845
EMP Simulator			87
Chemical Sprayer			174
Common Field Simulator Hard- ware		25	49
Totals	0	291	1471

is planned for GFY 1984 under the current contract. Additional details of the costs are provided in the subsequent subsections on each cost category.

#### 2.4.2 Estimated Development Costs

Costs for engineering development are shown in Table 9. Costs are based on engineering development of preliminary designs developed in the second increment of the current contract. It is assumed that although simulators will be ruggedly built, they will not be built to military standards and will not be type classified. Where possible off-the-shelf military or commercial components will be used in the design. Costs include limited engineering development testing. Costs of developing software to control simulators is included as a development cost; costs of integrating this software into the Core Instrumentation Subsystem computers is included under procurement costs.

The use of off-the-shelf, or modified, commercial pagers as a common type receiver/decoder for all field simulators has been investigated. There is some question as to whether the sensitivity of these pagers is adequate to provide the required reliability when using the maximum transmission power allowed for this application at Ft. Irwin. However, if these pagers are useable, the cost of developing a common field simulator receiver/decoder would be essentially zero. This latter approach would also reduce maintenance costs.

Development costs of field simulator control software is based on the following, where costs are in thousands of dollars:

Task ----	Man-Months -----	Cost ----
Development of requirements design specification (RDS)	2	12
Development of logic and programming	6	40
Development testing		47
Other direct costs		1 -----
Total		100

Table 9. Estimated development costs  
(thousands of dollars).

Item	Cost	GFY	Remarks
Simulator Transmission Module (STM)	30	85	Includes transmitter test in Phase IV Research
Simulator Field Modules (SFM)			
Common Field Simulator Receiver/Decoder	0		
Radiacmeter	100	85	Includes 30 K for testing.
Dosimeter	100	85	Includes 30 K for testing.
Chemical Alarm	100	85	Includes 30 K for testing.
Masking Timer/Casualty Indicator	230	85	Includes 30 K for testing.
		and	
		86	
EMP Simulator	70	86	Includes 20 K for testing.
Contamination Sprayer	20	86	Includes 10 K for testing.
Simulator Correlation Module (SCM) (Incl Bar Code Wand, Recorder, Transmitter/Receiver)	20	86	Includes 10 K for testing.
Field Simulator Control Software	135	85	Integration costs are listed under Procurement Costs.

### 2.4.3 Estimated Procurement Costs

Estimated procurement costs are shown in Table 10.

Integration of nuclear, chemical software for air/ground engagement simulation (AGES) is based on the following, where costs are in thousands of dollars\*:

Task No. -----	Task -----	Cost -----
1.	Project Mgt & Quality Assurance	60
2.	Software Enhancements	81
3.	Software Integration	68
4.	Acceptance Testing	34
5.	Operator Training	25
6.	Documentation	23
Total		----- 291

Integration of field simulator control software is based on the following where costs are in thousands of dollars:

Task -----	Man-month -----	Cost -----
Combining Software with AGES Software	3	19
Test and Evaluation		20
Acceptance Testing		40
Other Direct Costs		1
Total		----- 80

\* Based on proposal to TRADOC 28 June 1984.

Table 10. Estimated procurement costs  
(thousands of dollars).

Item	Unit Cost	Quantity	Total Cost	CFY	
Integration of Nuc/Chem SW for AGES	291	1	291	85	
Integration of Field Simulator Control SW	180	1	180	86	
Simulator Trans- mission Module (STM)	35	3	105	86	Incl \$ 10K/ site for shelter constructed at top of mountain.
Simulator Field Modules (SFM)					Electric power is assumed to be GFE at all three sites.
Radiacmeter	1.6	150	240	86	
Dosimeter	1.4	340	476	86	
Chemical Alarm	1.0	125	125	86	
Masking Timer/ Casualty Indicator	1.4	2400	3360	87	
EMP Simulator	0.9	300	270	87	
Chemical Sprayer	.8	300	240	87	
Simulator Correlation Module (SCM)	12	12	144	87	
Contact Team	15	1	15	86	
Vehicles & Radios		1	15	87	

Estimated unit costs for the radiacmeter field simulator are based on the following estimates. It is assumed that all field simulators have a common design receiver/decoder which would be specially produced. If an off-the-shelf pager could be used as the receiver/decoder, the receiver/decoder procurement costs would about half that shown.

Item ----	Cost ----
Receiver/decoder	\$ 500
Circuitry	400
Meter	300
Cast case and Webbing	200
Assembly and test	500
	----
Total	\$1600

Estimated unit costs for the dosimeter field simulator are based on the following estimates:

Item ----	Cost ----
Receiver/decoder	\$ 500
Circuitry	400
Case	100
Assembly and test	400
	----
Total	\$1400

Estimated unit costs for the chemical alarm adapter are based on the following estimates:

Item ----	Cost ----
Receiver/decoder	\$ 300
Circuitry	200
Cast case	200
Assembly and test	300
	----
Total	\$1000

Estimated unit costs for the masking timer/casualty indicator are based on the following estimates:

Item ----	Cost ----
Receiver/decoder	\$ 300
Mask transducer	200
Transmitter/receiver for masking signal	300

Other Circuitry	300
Packaging	100
Assembly and test	200
	----
Total	\$ 1400

Estimated costs for the EMP simulator are based on the following estimates:

Item	Cost
----	----
Receiver/decoder	\$ 300
Circuitry	250
Case	50
Assembly	300
	----
Total	\$ 900

Estimated costs for the chemical sprayer are based on the following estimate:

Item	Cost
----	----
Receiver/decoder	\$ 300
Circuitry	150
Case	50
Spray device	50
Assembly	250
	----
Total	\$ 800

Estimated costs for the Simulation Correlation Module are based on the following estimates:

Item	Cost
----	----
Bar code reader	Off-the-shelf
Recorder	Approx. \$11,000
Transmitter/receiver	
Assembly	
	----
Total	

Assembly costs were estimated to be on the order of fifty percent of the total cost for devices which were produced in small quantities. As quantities increased assembly costs were estimated to decrease to about thirty percent of the total cost. Assembly costs include a quality control test of each item.

#### 2.4.4 Operating Costs Estimates

The operating costs estimate is based on three types of costs: operations and maintenance (exclusive of repair parts), repair parts, and expendables.

Maintenance cost estimates are shown in Table 11.

Maintenance for the Simulator Transmission Module (STM) is estimated at four hours per week for each receiver/transmitter. One would operate from Mt. Tiefert and one Granite Peak.

Maintenance of the field simulator modules is estimated to average thirty minutes per rotation for the three initial simulator types (radiacmeter, dosimeter and chemical alarm). For the masking timer/casualty indicator these test procedures would use fixtures and procedures analogous to a production line. The EMP simulator is a fairly simple device requiring little maintenance. The chemical sprayer is more complicated and will require refilling.

Maintenance costs for software are based on five percent of the current proposal for operations and maintenance of the CIS software.

Maintenance of vehicles and radios to be used by a maintenance contact team is estimated at \$3000 per year, or \$60 per week per vehicle, including the radio.

Repair parts are estimated as ten percent per year of the procurement costs of hardware. Cost estimates for repair parts are in Table 12.

Batteries are estimated at one set of two batteries per receiver/decoder every ten weeks and one set to activate simulators every two weeks. This results in twenty sets per year per simulator. For alkaline batteries, which have the longer life than zinc carbon or zinc chloride, the cost in large lots is estimated at \$0.60 per set of two. This equates to \$12.00 per simulator per year. Costs of batteries are found in Table 13.

TABLE 11. Estimate of annual maintenance costs  
(thousands of dollars)  
does not include repair parts.

Item	Man-Hour/ Year/Device	No. of Devices	Total Man- Hours per year	Annual Cost	Start CFY
Simulator Transmission module (STM)	160	3	480	12	86
Simulator Field Modules (SFM)					
Radiacmeter	8	150	1,200	30	86
Dosimeter	8	340	2,720	68	86
Chemical Alarm	8	125	1,000	25	86
Masking Timer/ Casualty Indicator	8	2400	19,200	480	87
EMP Simulator	8	300	2,400	60	87
Chemical Sprayer	20	300	6,000	150	87
Simulator Correlation Module (SCM)	20	12	240	6	87
O & M of Nuclear/ Chemical Software for AGES				50	86
O & M of Field Simulator Control Software				50	87
Contact Team		1		3	86
Vehicles and Radios O & M		1		3	87

Cost per man-hour is estimated on the basis of a salary of \$25,000, 2.0 factor to include overhead, and 2000 man-hours per year.

Table 12. Estimate of annual costs of repair parts  
(thousands of dollars).

ITEM	COST	START GFY
Simulator Transmission Module (STM)	14	86
Simulator Field Module (SFM)		
Radiacmeter	24	86
Dosimeter	48	86
Chemical Alarm	13	86
Masking Timer/Casualty Indicator	336	87
EMP Simulator	27	87
Chemical Sprayer	24	87
Simulator Correlation Module (SCM)	15	87

Table 13. Estimate of annual expendables cost  
(thousands of dollars).

Batteries are AA alkaline penlight type costing sixty cents  
a set.

Device	Number of Operational Devices	Cost \$ K	Start FY
Radiacmeter	150	1.8	86
Dosimeter	340	4.1	86
Chemical Alarm	125	1.5	86
Masking Timer/ Casualty Indicator	2400	28.8	87

### SECTION 3 INTERFACES

Interfaces related to the introduction of the Nuclear/Chemical Field Simulator Component (N/C FSC) into the National Training Center (NTC) system have been analyzed in order to insure a viable design and as input in determining the technical and operational impact of the N/C FSC on the NTC. This analysis consisted of identifying each interface, determining the qualitative and quantitative characteristics of each interface, and identifying potential problems or constraints.

#### 3.1 Interface Identification

Interfaces were identified by determining the source of each output from the nuclear/chemical field simulator component (N/C FSC). Internal interfaces are between modules of the N/C FSC or another component of the CIS. External interfaces are between the N/C FSC and the other subsystems and components of the NTC. "Interfaces" are part of the overall NTC functional operation and do not include relationships which are not functionally designed into the system (e.g. interference with commercial RF or the Goldstone space tracking operation.) Consideration of these latter relationships are a part of a subsequent analysis in Section 4. Interfaces are summarized in Figure 2. In this chart, the NTC subsystems are shown on the diagonal. These subsystems consist of the Core Instrumentation Subsystem (CIS), the Range Data Measurement Subsystem (RDMS), and the Range Monitoring and Control Subsystem (RMCS). A block is also provided for "players", which includes both instrumented players and uninstrumented players. ("Instrumented" players have a device for the position location system (PLS) and a laser firing and hit recording capability; "uninstrumented" players do not have the PLS device.) The N/C FSC is also shown, with a block for each of its modules: the Simulator Correlation Module (SCM), the Simulator Transmission Module (STM) and Simulator Field Modules (SFM). The function of each of these modules is shown in the appropriate block. The components of the other NTC subsystems are listed in the diagonal blocks of those subsystems. Abbreviations used in these blocks not found elsewhere in this report are described in Appendix A.

Outputs of the diagonal blocks are shown on the same horizontal row. Inputs are shown in the same vertical column. In the following discussion, blocks are numbered using standard matrix notation (i, j), where "i" is the horizontal row number of the block reading from top to

1	2	3	4	5	6	7
CIS VVEC AND FSC CC DC LPS FTRC DPC	BIT CHECK FOR RECTIFY OF CORRELATION MESSAGES (FROM CC)	ENVIRONMENT/ EFFECTS MESSAGES TO SIMULATOR ADDRESS CODES			ENVIRONMENT AND EFFECTS TO FCC FROM CC)	
SIMULATOR ADDRESS CODE/ PLAYER OR UNIT CORRELATION TO CC	SCM INPUTS SIMULATOR ADDRESS AND UNIT/PLAYER DESIGNATION					
		STM TRANSMITS MESSAGES FROM CC TO SFM	ADDRESSES AND ENVIRONMENT/ EFFECTS MESSAGES			
			SFM PROVIDES READ- ING, ALARMS, KILL SIGNALS, SIMULANT SPRAYS		STATIC CHEMICAL DETECTOR/ALARM LOCATION OBSERVED BY FCC	ENVIRONMENT READINGS EFFECTS SIGNALS
(PLAYER/UNIT LOCATION) (B UNITS KILLED)				RDMS PTCC TCC PUC		
STATIC CHEMICAL ALARM LOCATION STATUS OF APCs				(OC ASSIGNMENT OF CASUALTIES TO B UNITS)	RMCS SAC ORC FCC LRC VVMC	(OC ASSIGNMENT OF CASUALTIES TO PLAYERS)
					(PLAYER POSTURE AND REACTION OBSERVED BY OC)	PLAYERS

☐ NC/FSC OF CIS

Figure 2. Nuclear/chemical field simulator component interface.

bottom and "j" is the vertical column number of the block reading from left to right. Thus Block (2, 5) contains the outputs from Block (2, 2) which are inputs to Block (5, 5).

### 3.2 Analysis of CIS Internal Interfaces

These are relationships between different N/C FSC modules or between an N/C FSC module and another component of the CIS.

#### 3.2.1 Simulator Correlation Module (SCM) to Computational Component (CC) of the CIS. (Row 2, Column 1)

The SCM collects and transmits the simulator digital address, and associated unit or player designation to the CC. The correlation message will require the following number of bits:

Bits Required -----	Content -----	Basis -----
9	Synchronization	
9	Simulator Address	512 Maximum Addresses
9	Message which activates field simulator	Needed resolution of readings on meters
9 -----	Bit Check	
36	Total	

Field simulator addresses will be assigned such that the type of field simulator (radiacmeter, dosimeter, chemical alarm, masking timer, EMP, and chemical sprayer) can be determined from the field simulator address. The quantities of simulators which will be required are shown in the preceding section. (Section 2)

For each company, the controller will scan bar codes containing the simulator information and enter the associated unit and player information and enter the information into the storage/transmission device which is part of the SCM. Simulator addresses are entered using a bar code reader. Unit or player designation is entered via a keyboard or by a bar code reader.

The following quantities of simulator messages consisting of simulator codes and associated unit addresses will be required per platoon for initial correlation immediately preceding an exercise:

Masking timers	1 to 4 codes
Radiacmeters	2 codes
Dosimeters	2 codes
Chemical alarms	2 codes
EMP Simulators	4 codes
Contamination Sprayers	4 codes
-----	
Total per Platoon	15 to 18 codes

Since each code will require a correlation message consisting of 36 bits, a maximum of 640 bits (plus control information) will be required to initially correlate one platoon.

The information will be transferred to the computational component of the CIS via a dedicated RF net. Information from a maximum of twenty BLUEFOR platoons will be entered during the initial correlation period, of about two hours. The transmission is via the two-way SCM RF link. In order to transmit the battalion combat team correlation information within one hour, about 13,000 bits must be transmitted, averaging 220 bits per minute. There appears to be no problem in providing the bit transmission rate required.

### 3.2.2 CC of the CIS to SCM (Row 1, Column 2)

The CC performs a bit check sum on the information which it receives from the SCM transmits a return message indicating that the transmission was received and that the bit sum checked properly or transmits an error message. The message contains the simulator designation and a status code. The same frequency is used for transmitting to and from the CC. Traffic from the CC to the SCM will be about one-third the volume of the SCM to the CC. It appears that this can easily be handled.

### 3.2.3 CC to Simulator Transmit Module (STM) (Row 1, Column 3)

The CC identifies which players and units are to be provided nuclear and chemical information and translates the player/unit designations to simulator address codes. The STM transmits this information to the simulator field modules. The CC is physically connected by a coaxial cable to the STM transmitter.

As discussed below, the CC may also execute a logic which assigns priorities to messages and eliminates unnecessary repeated transmission of messages for certain field simulator types. Since the computer may operate much faster than the field simulators can react to messages, some logic, including message priorities, may be implemented in the computer to reduce message traffic peaks which could exceed an RF transmission rate selected to match the field

simulator receiver/decoder capacity.

3.2.4 STM to Simulator Field Modules (SFM) (Row 3, Column 4)  
The STM transmits the address code and instructions generated by the CC, and discussed in the preceding paragraphs to the Simulator Field Modules (SFM). Simulator Field Modules all have a common receiver design. The output of the STM is a 27 bit code.

The SFM's do not transmit, so the communication is one-way. An update is transmitted to each SFM as required (on the order of every two minutes). Each message contains the following information:

Content	Bits
-----	----
Synchronization	9
Simulator address	9
Message information	9
	-----
Total Maximum	27

Timing constraints are discussed below in Section 4.2. To update all the simulators in two BTF and one OPFOR every minute would require 320 bits per second. It appears this requirement can easily be met by the RF transmitter; however, receiver/decoder message handling rates may not be compatible with this theoretical maximum.

If scenarios are constrained, as described in Section 4.2, the required message rates can be reduced considerably. It appears that realistic message handling rates will be between five messages to ten messages per second.

### 3.3 Analysis of External Interfaces

These are interfaces between the N/C FSC and other subsystems or components of the NTC.

#### 3.3.1 SFM to RMCS (Row 4, Column 6)

Field controllers will be required to observe when chemical detectors are emplaced in a static location, and to identify the coordinates of that location. This will require the attention of the field controller, but the task is consistent with other field controller tasks and the additional task is not expected to be a problem. The overall impact on field controller workload will be considered in Section 5.

#### 3.3.2 SFM to Players (Row 4, Column 7)

The SFM communicates environment and effects to players.

The outputs of the SFM depend upon the type of field simulator. The radiacmeter simulator outputs a dial reading of the local radiation rate to the operator. The dosimeter simulator causes a total dose reading to be entered in a device which sets an actual dosimeter. The chemical alarm activates an alarm audible to participating troops.

The masking timer/casualty indicator sends a kill signal to all individual and to all vehicles with collective protection systems in the area covered by the chemical agent. If a soldier or key members of the vehicle crew are masked before the kill signal arrives, a short range output of the masking timer prevents the kill signal from operating the kill indicator. The kill indicator, e.g., a shutter on the back of a soldier or a light on the vehicle provides localized information that a soldier or player is a chemical casualty. An interface may be provided to the individual or vehicular MILES unit so that signals from the casualty indicator can cause the MILES kill lights of individuals and players to be activated and cause their weapons to be disabled.

The EMP simulator provides an interruption of the radios of selected players. The chemical contamination simulator produces a short puff of chemical agent simulant on the surface of the vehicle on which it is mounted.

These interfaces require that the outputs of the simulator be readily and realistically observable by the players and controllers. Further design and analysis will be required to insure that the outputs will be observable, as required, and still not provide more information than would be available in an actual battle.

### 3.3.3 Range Monitoring and Control Subsystem (RMCS) to CIS (Row 6 Column 1)

Field controllers of the RMCS will be required to observe when task organization is changed resulting in changing player attachments. This information is then sent to the CIS via an existing RF link which is part of the simulator transmission module. Field controllers will also be required to report when infantrymen are inside APCs and when they are outside. This will be required in order for the CIS to compute the appropriate total dose and dose rates for transmission to dosimeter and radiacmeter simulators. The overall impact on field controller work load will be considered in another part of this research task.

The Field Operational Controller Component (OC) of the RMCS will notify the CIS of the casualties which the OC has assessed. Casualties will be identified by player or unit, and percentage. Other information may also be required such as type of casualty (nuclear or chemical). The OC will also supply locations in terms standard UMT coordinates and alarm

address codes for static chemical detector/alarms which have been emplaced. All communicators from the OC to the CIS will be via the voice RF net.

### 3.4 Non N/C FSC Interfaces Related to N/C Operations

These are interfaces between subsystems of the NTC which are modified by the introduction of the nuclear/chemical training enhancement, but which do not directly involve the N/C FSM. In Figure 2 these interfaces are shown in parenthesis.

#### 3.4.1 CC to RMCS Interface (Row 1, Column 6)

The CC will produce warnings that nuclear or chemical attacks will occur in five minutes and in one minute. These are for controller use only so that they can ready themselves to best observe, evaluate, and record player actions and when necessary assign casualties. The CC will also produce messages on the percent of casualties and types of casualties to be assigned to each unit due to immediate effects. This information will be forwarded to the OC by means of the existing RF voice net using a format and procedures similar to those now used for indirect fire.

The CC will also keep track of nuclear radiation doses and chemical contamination and provide casualty recommendations when delayed effects occur, to the OC via the existing RF voice net. Recommendations will consist of percent casualties by platoon due to delayed nuclear effects and delayed chemical permeation of protective equipment.

#### 3.4.2 RMCS to RDMS Interface (Row 6, Column 5)

The field controllers of the RMCS will use their MILES designators to assign kills to B units in the Player Unit Components (PUC) of the RDMS when kills are recommended by the CC due to nuclear or chemical effects.

#### 3.4.3 RDMS to CIS (Row 5, Column 1)

The kills which are recorded in the PUC of the RDMS will be automatically transmitted to the CIS.

The Position Tracking and Computational Component (PTCC) of the RDMS will also provide player and unit location to the CIS as is currently done. This location information will be used at the CIS to compute the nuclear and chemical effects on those players and units.

#### 3.4.4 RMCS to Players (Row 6, Column 7)

OC's will assign casualties to noninstrumented players due to initial nuclear and delayed nuclear and chemical effects

in the same manner as is currently done for indirect fire. Recommendations for quantities of casualties to be assigned will be provided by the CIS as described in Section 3.4.1 above.

3.4.5 Player to RMCS (Row 7, Column 6)  
OC's will observe player postures and reactions as one basis for allocating casualties due to nuclear and chemical effects.

## SECTION 4 TECHNICAL ISSUES AND IMPACTS

This section describes analysis of technical issues which affect the development and use of field simulators. Selections of the issues are based on a perceived development risk, compatibility problems, potential high costs, or performance shortfall. Technical issues which were analyzed are as follows:

- Radio frequency transmission constraints and coverage
- Timing constraints
- Computer capacity for adding simulator requirements
- Masking simulator/casualty indicator feasibility

### 4.1 Radio Frequency Transmission Constraints and Coverage

The operator of the field simulators proposed for nuclear and chemical warfare training at NTC is dependent on reliable reception radio frequency (RF) signals by the simulators.

#### 4.1.1 RF Transmission Constraints

There are several constraints in use of RF energy at the NTC. The Goldstone space communication system is located near the NTC ranges, this limits RF at NTC to that which will not interfere with Goldstone. On the NTC itself there are several military radio nets, mostly operating at from 30 to 60 megahertz (MHz). There may also be Air Force nets operating in the UHF band. The position location system (PLS) of the NTC also operates in RF. There are commercial broadcast bands to consider. The requirement not to interfere with existing RF applications limits the available frequencies and the power level. Allocation of frequencies and power levels is controlled by the spectrum management office (SMO) at Ft. Irwin. The service is provided by a contractor to the Federal Government. Currently available frequencies at 148.2 MHz and 410 MHz have been tested; however, recent information indicates that several other frequencies may be available for the field simulator application. Power level at these frequencies can be on the order of one kilowatt.

Transmission sites are also limited. Because of the steepness of the mountains, sites at high elevation need to be grouped in order to reduce the cost of site preparation,

power delivery, and cost of resupply (mostly by helicopter) and maintenance. The very highest peaks at both Tieford Mountain and Granite Peak are used for the spectrum management receivers and military receivers. Since the spectrum management receivers monitor across the frequencies which would be used by the field simulator transmitters, the transmitters must be located some distance away.

There are available sites, where other transmitters are located, complete with power, on both Tieford and Granite Mountains. These sites were used in recent RF tests described in the next paragraph, and would be available for the field simulator transmitters.

#### **4.1.2 RF Tests**

In order to further define problems which might be increased in RF reception, a preliminary, low-cost test was conducted on October 27 and 28 through 1983 at Ft. Irwin. This test consisted of transmitting at known power levels from the available sites at Mt. Tieford and at Granite Peak; and measuring the signal strength received at a few selected locations. Locations were selected to give a sampling in areas where communications were known to be a problem in the South Corridor, Central Corridor and Live Fire Range. Reception was also measured at points where reception was likely to be good, to provide control data. The report on the test is included in Appendix B.

In the tests the highest measured path losses were 169.5 dB at 410 MHz and 163.1 dB at 148 MHz. The off-the-shelf pager being considered has a sensitivity threshold of 3 microvolts. This will require a transmitter effective power of 56 KW. This power is several times in excess of what could be used at the NTC. One kilowatt is a reasonable estimate of the acceptable power level.

If all transmissions are sequentially transmitted from two sites, rather than Mt. Tieford alone, the received signal strength may be increased 20 dB or more in many, but not all cases. This may be seen by comparing the measured paths on pages 7-12 of Appendix B.

Directional transmission antennas which direct the energy at the horizontal or below may add 4 dB to the effective transmitter power while actually reducing the probability of interface with Goldstone.

#### **4.1.3 Conclusions and Recommendations**

It appears that more sensitive receivers and/or lower path loss are required for dependable operation. Since the concept of controlling simulators by RF signals is dependent on reliable receipt of signals, an extension of the RF

coverage test is desirable. This test would utilize higher power transmitters if acceptable and receiver/decoders which would be the prototype of the common front end of all field simulators. Transmission of a coded address and message would be repeated alternately from Tieford and Granite transmitter sites, and any area where a signal was not received would be mapped.

Concurrent with this test, field strength measurements would be made in areas where receipt was not successful, so that changes needed in receiver sensitivity and/or transmitter power levels could be determined

Use of a lower frequency should be checked. Alternate RF frequencies in the 1.6 MHz to 3 MHz range should be evaluated if the SMC indicates that a frequency in this range is available for operational use.

The use of a mobile relay in the vicinity of the simulators should also be investigated.

#### 4.2 Timing Constraints

Depending on the design of the receiver/decoder and the approach to sending simulator control messages, the time to cycle through one update of all simulators could be significant.

As may be seen from Table 3, after deducting quantities of simulators on the maintenance float, a maximum of about 3300 field simulators could be operating at one time. As may be seen in Section 3.2.1, these simulators would have from 15 to 18 codes per platoon, or a total of about 1000 codes including limited quantities of OFFOR field simulators. Each simulator message, including synchronization and address, would require 27 bits. With a spacing of 9 bits between messages, 36 bits would be required for each transmission. Each simulator message would be sent twice in sequence, once via Tieford and once more via Granite. If the relay is on the same frequency as the CIS transmitters, each message would have to be sent four times. This would result in 4000 messages per cycle with a total of 144,000 bits. If a cycle is two minutes long, a bit rate of 1200 per second is required. While this is attainable by the computer and the RF transmission system, it probably exceeds the speed of an off-the-shelf pager.

In actuality it appears that considerably lower data rates will be acceptable. Table 14 shows nuclear field simulators. Table 15 shows the times when nuclear field simulators could be used, based on the requirements in the previous table. Table 15 is for two BTFS.

Table 14. Nuclear field simulators timing requirements.

Field Simulator type	Start Event	Approximate Frequency of Use	Stop Event	Required Update Interval	Approximate Number of Addresses	Remarks
Radiacmeter	Warning or occurrence of a nuclear event	5 minutes to 24 hours (Reconnaissance)	Rad level below 0.1	4 minutes	70/BTF	Output is meter reading
Dustmeter	Warning or occurrence of a nuclear event	1 to 24 hours	Remainder of exercise	30 minutes	150/BTF	Output is meter reading
Chemical Alarm	Chemical cloud encompasses detector	One per 6 hours	Completion of first transmission	2 hours	60/BTF	Output is yes/no
Masking Timer/Casualty Indicator	15-30 seconds after troops subjected to chemical attack	One per 6 hours	End of chemical threat	2 minutes	1200/BTF	Output is yes/no Retransmitted periodically to indicate vulnerability and insure continued masking Follows chemical alarm
TMP Simulator	Immediately following nuclear burst	About 3 times per exercise	One message per nuclear burst	None	200/BTF (incl UPFOR)	Output is yes/no
Chemical Sprayer	Immediately following exposure to chemical agent	About 3 times per exercise	One message per exposure	None	150/BTF	Output is yes/no

Table 15. Times when nuclear field simulators are used.

Nuclear event at time (T) = 0

Simulator	Time Start	Time Stop	Frequency of update	Number of addresses
Radiacmeter	T-30 min	T+3 days	2 min	140
Dosimeter	T-30 min	T+3 days	30 min	300
EMP Simulator	T	(one time)	(one time)	30

Thus the longest demand is for the message to the radiacmeters and dosimeters. Radiacmeters would require 140 messages every 2 minutes or one message every 0.857 seconds. Dosimeters would require 300 messages in 30 minutes or one message every 6 seconds. EMP simulators would require messages to about 30 vulnerable players in a short time. Thirty seconds would be acceptable. Thus a nuclear burst would require a message rate of 1 message per second for the nuclear pulse for a period of thirty seconds. These messages can be sent before the messages to radiacmeters and dosimeters. This is based on the assumption that the CIS computer will send messages to "yes/no" type simulators only when a "yes" output is desired. The radiacmeters and dosimeters would require one message every 0.857 seconds and six seconds respectively. The combined interval is given by:

$$1/T = 1/.857 + 1/6 \text{ or } T = 0.750 \text{ seconds per message transmission.}$$

If each message is transmitted four times, the maximum time is 0.187 seconds per message. Based on 36 bits per message, the bit rate is 193 bits per second.

Table 16 shows the times when chemical field simulators would be used for two BTFs. It is assumed that the chemical attack will affect two companies in each BTF and that their times will overlap.

Table 16. Times when chemical field simulators are used.

Chemical attack at T = 0

Simulator	Time Start	Time Stop	Frequency of update	Number of addresses
Chemical Alarm	T	(One Time)	(One Time)	10
Masking Timer Casualty Indicator	T+5 seconds	Approximately T+3 days maximum	2 Minute	64*
Chemical Sprayer	T+5 seconds	(One Time)	(One Time)	64

The only continuing demand in a chemical attack is the masking timer casualty indicator to which a signal (kill signal) is repeatedly sent so that a casualty is indicated if anyone removes his mask while the chemical agent is present. Sending a message every minute should provide this, although in some cases a man could briefly remove his mask without a kill signal being processed. To send a signal every minute to 64 addresses will require one message every second. The chemical alarm messages are sent one time for each chemical attack. Addressing each alarm within 5 seconds will probably be sufficient, so that this will require 10 messages at the rate of one per half second. The chemical sprayer also requires a single message per address.

The detection of the chemical spray will take somewhat longer than the alarm or masking. Spraying each of 64 devices within one minute should be fast enough. This later action can be delayed until after the initial chemical alarm and masking timer/casualty indicator signal have been sent. If chemical alarms are sent first, masking timers sent after five seconds, and chemical sprayer messages after three minutes the rates in Table 17 are required.

\* Depending on whether all vehicles have individual mask codes, or mask codes are one per platoon.

Table 17. Required rates for chemical simulator messages.

Time	Simulator	Required Message Rate per Address
T to T+5 sec.	Chemical Alarm	One time. One per half second
T+5 sec to approx T+3 hours	Masking Timer/ Casualty Indicator	One per second
T+5 sec to T+2 minutes	Chemical Sprayer	One time. One per two seconds

The above require a rate of twenty messages per second for the first five seconds. Following this all masking timers should be addressed within one minute and all chemical sprayers within three minutes. Each masking timer should be subsequently addressed every two minutes. The maximum bit rate required for a chemical event is 128 bits per second. This occurs in the first five seconds. After the first three minutes, 35 bits per second are required for one chemical event without relay.

If all nuclear and chemical operation start times are spread by at least three minutes, nuclear and chemical events in each of two BTF's will require a rate of 333 bits/second. This is based on each message sent twice (once to Tiefert and once to Granite) and each message relayed once. Each message contains up to thirty-six bits. This allows a third of the time for spacing. The message rate requirement can be reduced by limiting the scenario to the effects of only one nuclear attack and one chemical attack or two nuclear attacks to occur at the same time. However, once a nuclear attack has occurred, radiacmeters and dosimeters will probably be used at regular intervals to monitor the environment throughout the training segment.

#### 4.3 Computer Capacity

The computer component (CC) of the CIS will be used to provide messages for field simulators. It is essential that the computer have the capability for the additional storage and processing required.

The computer will be required to perform the following additional tasks due to the addition of field simulators:

Store field simulator digital address codes and the designation of the unit or player or location of the field simulator.

Extract from the data base, which is updated at least every two minutes, the following information:

- a. Radiation rate at each radiacmeter location
- b. Accumulated dose for each player or unit to which a dosimeter is assigned.
- c. Presence or nonpresence of a chemical agent at each chemical detector location.
- d. Presence or nonpresence of a chemical agent at each platoon or player location.
- e. Vulnerability status to EMP of each player radio.

The data base containing this information will already have been generated and is not required for the sole purpose of field simulator initialization.

The computer will format an appropriate field simulator control message for each simulator to which nuclear or chemical effects apply. It will skip over messages if there is no information to be sent. In other words if the output of a "yes/no" type simulator is "no", a message will not be sent. The computer will convert the environmental information to the appropriate simulator control message. It will also convert the unit or player designation to the appropriate simulator digital address. It will then output the combined simulator address and control message. Each message with address and spacing will be thirty-six bits. For two battalion task forces (BTF) simultaneously at the NTC there will be 333 bits (or approximately ten messages) per second required.

An analysis of the current computer capability and requirements indicates that there is adequate processor capability and storage capacity for the additional requirements imposed by field simulators.

#### 4.4 Masking Timer/Casualty Indicator Feasibility

A critical action in chemical warfare is donning the protective mask in time to avoid becoming a casualty. At the same time, wearing the mask is uncomfortable, constricts breathing, and reduces vision. In training, there is naturally a strong tendency to avoid wearing the mask. Due to the wide area covered by trainees, with many trainees inside tanks or APC's, it is very difficult for field controllers to observe if masks are donned properly, donned in time, and are continuously worn. The short critical time

period for donning the masks further complicates field controllers' effective evaluation. Therefore, for chemical warfare training a device which determines when masks are worn is highly desirable.

In the NTC application there are several constraints on the design of a masking timer/casualty indicator. The device must not be obvious or artificially constraining; e.g., wires should not create an unnatural connection and constraint between the mask and the soldiers body. The device must be reliable. It must also operate in real time, so that casualties are assessed in the same time period in which they would actually occur. The device should allow personnel protected inside tanks or APC's additional time for masking. The device must also work for both individual protective masks and masks in vehicle collective protective system.

The concept proposed uses a kill signal digitally addressed to units or players in concentrations of disabling chemical agents. This kill signal is analagous in area and effect to a chemical agent. When the mask is worn, the kill signal is interrupted; interrupting the kill signal is analagous to filtering out the harmful agent.

The design of the masking/timer casualty indicator is dependent on a transducer which senses that the mask is properly worn, and if so, generates a signal which can be used to interrupt the kill signal. The U.S. Army Combat Developments Experimental Command (USA CDEC) has been working for several months to develop such a transducer. The Jet Propulsion Laboratory (JPL) also has a contract to develop a masking timer. Both used meters to measure the flow of air through a device replacing one of the standard filters in the mask. CDEC has found that even with flow meters sensitive to as low as a half inch of water equivalent pressure, the meters give frequent false alarms when soldiers are inactive, and consequently are breathing quietly. CDEC is currently developing another transducer consisting of a bridge circuit which compares the difference in temperatures between two points in the mask. The difference in temperatures will provide a measure of when the mask is worn. Output of the transducer is used by CDEC to time when the mask is worn, or removed. This information is stored for later retrieval. The output could be modified to interrupt the kill signal in the NTC application. The bridgewire transducer will probably also work in the collective devices. A flow meter probably would not work in collective protection systems due to the continuous high air flow. The latest CDEC approach will be tested in December 1983 or January 1984. It appears that CDEC has a strong need for a masking timer so that one will be developed by them in the near future. Considerable development savings could be realized by using the principle of the transducer which CDEC ultimately develops.

In the NTC masking timer/casualty indicator concept there is also an untested approach to transmitting a signal from the mask to interrupt a kill signal in a small receiver worn by the soldier. It is theoretically possible to transmit this information using a very low power receiver worn by the trainee. About ten frequencies could be used to provide a sufficient probability that at random a signal due to masking of one soldier would not protect another nearby soldier. The concept appears to be well within the state of the art.

A third uncertainty in the concept is how to most effectively indicate chemical casualties. A blinking light may be too conspicuous and require too much power. A shutter device would require less power and could be read for some distance. These are a number of approaches to indicate casualties which need to be considered in terms of exercise realism, field controller convenience, and development, procurement, and maintenance costs. All approaches appear to be low risk, within the state of the art.

## SECTION 5 OPERATIONAL ISSUES AND IMPACTS

Operational issues and their impacts were divided into two categories: training and logistics.

### 5.1 Training Issues and Impacts

Training issues which appear to be potentially significant are changes in trainee environment, changes in trainee and controller workload, changes in training emphasis, effects on realism and training constraints, and applicability of the chemical sprayer.

#### 5.1.1 Changes in Trainee Environment:

There appear to be no significant changes in the elements of the trainee environment from the current environment when the scenarios include the same chemical and nuclear effects; however, the nuclear and chemical environment with simulators may be more constraining and more demanding. Radiacmeters and dosimeters will provide a continuous update of radiation hazards, but to be useful, they must be frequently read and appropriate reports and records processed. Chemical alarms must be properly positioned in static situations and must be used in chemical reconnaissances. Masks must be promptly and correctly put on, and left on until the danger is past. Radios which are not shut down may be disabled requiring a field controller to reset the radio after simulated repair or replacement has been effected. Contaminated vehicles must be washed down.

#### 5.1.2 Training Emphasis

As in the case of training environment, training emphasis is scenario dependent. However the realism added by consistent radiacmeter and dosimeter reading, timely chemical detector and alarm activation, prompt and comprehensive assessment of casualties due to improper masking, and prompt, highly visible effects of EMP and contamination will result in increased emphasis on nuclear and chemical warfare training when the same scenarios are used. This increased emphasis, however, does not appear to be inordinate. If the state of training is such that troops are not ready for the increased emphasis on nuclear and chemical training, scenarios can be modified to reduce nuclear and chemical warfare emphasis.

#### 5.1.3 Realism

Certain aspects of realism will be increased and certain aspects decreased. Readings on radiacmeter and dosimeters

and activation of chemical alarms will be close to those which would be actually experienced for the simulated environment as stored in the computer. Assessment of prompt and delayed casualties will also be consistent. Disabling of radios will approximate real effects. Contamination of vehicles will be relatively unobtrusive and in real time.

There are some inevitable reductions in realism. Depending on the frequency finally selected, meters and detectors may have an antenna added. Before each reading, the dosimeter must be inserted in the canteen sized reading device which is carried by the dosimeter operator.

Limitations on quantities of individual codes, due to processing requirements, as well as the capability to locate individuals, require that all individuals in a dismounted platoon are subjected to a chemical attack at the same time.

When there are simulator failures some backup methods of operation must be used. Backups, in general, can be provided by controller intervention; e.g., a field controller telling a dosimeter operator the dose that would be read on the dosimeter. Thus the fallback position, would in most cases, have the realism of current training without simulators.

The net effect of simulators appears to be significant increases in training realism.

#### 5.1.4 Controller Workload

For a given level of nuclear/chemical warfare training the net workload of both CIS controllers and field controllers will be reduced. There will be some additions to workloads of both types of controllers. At the beginning of the exercise the addresses of all simulators must be correlated with the identification of units/players to which they are assigned. Cross attachments of dismounted troops below platoon level during the exercise will require recorelation during the exercise; however, cross attachment at this level will seldom, if ever occur. Using the bar code reader, a platoon-sized unit designation must first be read and then the bar code of all simulators assigned to that unit must be scanned. This process will take an estimated thirty minutes per platoon per exercise before the exercise begins.

During the exercise, if simulators are used in radiological or chemical reconnaissance, the simulators must be correlated with B units of the vehicles on which they are carried, or the controller must report each position when readings are taken.

In order for appropriate radiation shielding effects to be considered, the field controllers must keep the CIS informed as to whether mechanized infantry are inside or outside APC's. This does not appear to be an insurmountable problem, since this information is probably significant in AAR's and will be reported in the current system.

When chemical detectors/alarms are emplaced in a static position the field controller must provide the location and simulator address to the CIS. The CIS controller will enter the information using an interactive menu.

Chemical masking timer/casualty indicators will activate a kill indicator for a chemical casualty for dismounted individuals and for players. The current concept is that based on the activation of the kill indicator, the field controller will assign chemical casualties. In this respect, while the chemical masking timer/casualty indicator does require field controllers to assign casualties, the process of assigning casualties will be greatly facilitated.

Activation of readings on simulators of radiacmeters, dosimeters, and chemical alarms will greatly reduce the field controller work load if the monitoring of these devices is part of the training.

Use of EMP simulators will greatly increase realism with the capability to simultaneously affect several radios. After radios have been disabled, to reenale the radio, simulating repair or replacement, will require that the field controller physically use a key for reenabling.

#### 5.1.5 Applicability of the Chemical Sprayer

Currently there are two capabilities for contaminating vehicles with a chemical simulant. The first is an aerosol delivered by aircraft from spray tanks. The second approach is the SPAL simulated projectile airburst launcher which can deliver about six projectiles over an area about a hundred yards across. The air spray can be used in essentially the same conditions as an actual aircraft spray, although correlation of the spray pattern on the ground and as calculated in the computer may be difficult. The SPAL device requires launching in vicinity of the target, but a locally developed launcher, unobtrusively mounted on a controller's 1/4 ton truck has been used with considerable success at NTC. Although the proposed chemical sprayer would provide better control of which vehicles are contaminated, and allow for remote contamination, operation officers at the NTC have indicated that the chemical sprayer does not now provide enough advantage over the current capability to warrant its development.

## 5.2 Effect on Logistics

These effects include supply and maintenance changes. Logistics requirements and the logistics concept are described above in Section 2.3

### 5.2.1 Supply

At the beginning of each exercise simulators will be issued. Simulators which are installed on vehicles (EMP and chemical sprayers) will be issued as installed equipment on vehicles. Other simulators will be issued to company commanders at the same time as other NTC equipment (e.g. individual MILES equipment). Currently MILES and other equipment including that on vehicles is checked out following issue. Field simulators would be checked out at the same time. This will include a transmission to each simulator address to test that the simulator is working. This will be followed by reset of the simulators. Logistics personnel will be present at this test to exchange on a one-for-one basis any equipment found to be deficient. Tests will be conducted in conjunction with initial correlation of simulator address codes with unit identification.

### 5.2.2 Maintenance

Maintenance will consist of limited replacement or unscheduled maintenance in the field during exercises; scheduled testing, maintenance and limited repair between exercises; and scheduled maintenance and repair of the maintenance float during the conduct of exercises.

Table 18 provides an estimate of the manpower required maintenance and repair activities between exercises.

Table 19 provides an estimate of the manpower required for maintenance and repair activities during exercise for one BTF.

Table 18. Maintenance between rotations.

Equipment	Actions Required	Hours per item	Number of items	Total hours
-----	-----	-----	-----	-----
Radiacmeter	Test, change batteries	1/6	70	11.7
Dosimeter	Test, change batteries	1/6	154	25.7
Chemical Alarm	Test, change batteries	1/6	57	9.5
Mask Timer/ Casualty Indicator	Sterilize, test, change batteries	1/6	1071	178.5
EMP Simulator	Test on tank/APC	1/6	150	25.0
Chemical Sprayer	Refill, test on tank/APC	1/3	150	50
				-----
				300.4

Table 19. Weekly scheduled maintenance and repair.

Equipment	Hours per Item	Numbers of Items	Total Hours
-----	-----	-----	-----
Radiacmeter	2	8	16
Dosimeter	2	17	34
Chemical Alarm	2	7	14
Masking Timers	2	120	240
EMP	2	15	30
Chemical Sprayer	6	15	90
			-----
		Total	424

Assumes 5% serviced per week or each item serviced twice every year.

From these tables it can be seen that the critical requirement is the maintenance between rotations. In three eight hour days this will require 13 men. To accomplish the weekly maintenance in a forty hour work week will require eleven men. In order to provide the required hours estimated in the logistics concept (Table 11) would require 18 men working forty hours a week, 46 weeks a year (to allow for vacation, holidays, sickness and other nonproductive time). Adding ten percent for supervision, then ten percent for supply support and ten percent administration gives 24 men total.

Of these twenty-four, 18 would be electromechanical technicians, 2 would be supply specialists, 2 would be administrators, and 2 would be supervisors. The two team technicians would be part of the electromechanical technicians.

Storage and maintenance space would be required. An estimated two thousand square feet of maintenance and storage space would be required. This is based on 50 square feet for each of 24 workers plus 800 square feet for storage.

## SECTION 6 CONCLUSIONS

### 6.1 Training Effectiveness

Field simulators will significantly enhance training in nuclear and chemical warfare at the NTC. Realism will be increased and emphasis on nuclear and chemical warfare will be appropriately intensified when these effects are included in the scenario. Field simulators will provide more timely and more consistent information to trainees and will improve evaluation of trainee actions.

There is some doubt as to the need for the chemical sprayer simulator since its function is currently performed by aerial spray and the SPAL device.

### 6.2 Resources Required

Resources required for the procurement and operation of the common elements, radiacmeter, dosimeter, and chemical alarm simulators would be less than twenty percent of the estimated procurement costs and operating costs for the entire system. The masking timer/casualty indicators, EMP simulators, and chemical sprayers are provided to each player or each trainee. Due to the large number of these field simulators, they account for over eighty percent of the estimated procurement costs and operating costs.

### 6.3 Interfaces

Identification and analysis of interfaces concludes that field simulators can be accommodated within the existing hardware system and operational approach. Initialization of interfaces at the beginning of a rotation can be handled initially as is currently done with "B" units. The proposed field simulator correlation module will be desirable when large quantities of field simulators become operational. Increased storage and processing requirements are within the capability of the computational component. Timing requirements for transmission of simulator control messages are not severe in terms of computer or RF transmission rates, but could affect decoder selection.

### 6.4 Technical Issues

RF tests have provided a basis for calculating transmission losses, so that for a given transmitter power level, location, and frequency the required receiver/decoder sensitivity can be more accurately estimated. The

sensitivity of off-the-shelf pagers which have been considered will not provide the needed reliability of receipt of field simulator control messages throughout the NTC South Corridor, Central Corridor, and Live Fire Range.

The transducer which provides an output signal when the mask is properly worn has not been developed. However U.S. Army CDEC has an effort to develop a transducer to measure when masks are worn. The transducer resulting from this effort will probably satisfy the NTC field simulator requirement.

#### 6.5 Operational Issues

Changes in training environment due to simulators will place increased emphasis on procedures to be followed in nuclear and chemical warfare and increase realism. Negative effects on the training environment appear to be insignificant. Artificialities will be less than in the current system when a nuclear or chemical warfare is included in the scenario.

Field controllers will have the added responsibility of initializing field simulators before the exercise by correlating simulators addresses and player/unit designations. Field controllers will have the additional tasks of reporting location of static chemical detector/alarms, reporting when platoon exit APC's and assessing casualties for nuclear and chemical effects based on recommendations from the CIS. These additional requirements appear to be within the capability of field controllers and are less than the workload required by current nuclear or chemical training in a corresponding scenario.

## SECTION 7 RECOMMENDATIONS

### 7.1 Phased Implementation

It is recommended that a field simulator system be implemented in a phased program to reduce development risk and costs and allow for programmatic decisions based on development and operational experience. Phasing is shown in Figure 3. In this sequence it is recommended that chemical sprayers be an option for planning purposes but that funds and effort not be expended in their development or procurement until their need has been more positively established.

### 7.2 Insure Reliable RF Reception

It is recommended that the next immediate step be identification or development of a receiver/decoder. When combined with available transmitter frequency, location, and power levels this receiver/decoder must provide a high probability of operation. The steps in this effort should include the following:

1. Determination of receiver/decoder required sensitivity based on RF tests already conducted.
2. Identification of existing pagers which meet the requirement and procurement of a few pagers for testing.
3. If promising pagers are not available off-the-shelf, design and fabricate test receivers/decoders with the required sensitivity.
4. Test off-the-shelf pagers or specially fabricated pagers, as applicable, at Ft. Irwin, with appropriate transmission conditions.

### 7.3 Reserve RF Frequencies, Sites, Power Levels

It is recommended that permission to operate on an acceptable frequency, at required power levels, and from appropriate sites for use of field simulators be confirmed in the near future in writing.

	GFY 85	GFY 86	GFY 87
ENGINEERING DEVELOPMENT	COMMON FIELD SIMULATOR HDW	MASK (2/3)	
		EMP	
	RADIACMETER	CHEM	
	DOSIMETER CHEM ALARM MASK (1/3)	SPRAYER*	
PROCUREMENT/ OPERATION	NUC/CHEM SOFTWARE	COMMON FIELD SIM HDW	MASK
			EMP
		RADIACMETER	
			CHEM SPRAYER*
		DOSIMETER CHEM ALARM	

\* IF IMPLEMENTED

Figure 3. Phased approach.

#### 7.4 Simulator Correlation Module

It is recommended that a Simulation Correlation Module, as described in Section 1.3, be acquired to facilitate initial correlation of field simulator addresses and unit identification just prior to each rotation. This module will not be required until the second, most numerous group of simulators are acquired in GFY 1987.

#### 7.5 Masking Timer/Casualty Indicator

It is recommended that close coordination be maintained with the program at CDEC for the masking timer. This will permit maximum utilization of that on-going development in NTC program.

#### 7.6 Continuing Development in DNA Program

It is recommended that following the identification or development of receivers/decoders desired in Section 7.2 above, prototypes of radiacmeter simulators, dosimeter simulators, and chemical alarm simulators be designed and breadboards be constructed as part of the DNA NTC IB program.

ATTACHMENT 1  
ACRONYMS USED IN THIS REPORT

AA	Antiaircraft
AGES	Air ground engagement simulation
APC	Armored personnel carrier
BLUEFOR	Blue Force (U.S. or allied forces)
BMP/ZSU	Warsaw Pact armored personnel carrier/ Warsaw Pact track mounted 23 mm anti- aircraft gun
BTF	Battalion task force
CC	Computational Component
CDEC	Combat Development Experimental Command
CIS	Core Instrumentation Subsystem
DNA	Defense Nuclear Agency
EMP	Electromagnetic pulse (generated by a nuclear detonation)
GFY	Government fiscal year (October through September)
JPL	Jet Propulsion Laboratory
M/H	Man-hours
MHz	Megahertz (millions of cycles per second)
MILES	Multiple Integrated Laser Engagement Simulator
N/C	Nuclear/Chemical
N/C FSC	Nuclear/Chemical Field Simulator Component
NTC	National Training Center

OC	Field operational controller
OPFOR	Opposing force (enemy)
PLS	Position location subsystem
RDMS	Range Data Measurement Subsystem
RDS	Requirements design specification
RF	Radio frequency
RMCS	Range Monitoring and Control Subsystem
SCM	Simulator Correlation Module
SFM	Simulator Field Module
Sgt. York	Future U.S. track mounted anti-aircraft gun
SPAL	Simulated Projectile Airburst Launcher
STM	Simulator Transmission Module
TOE	Table of organization and equipment
TRADOC	Training and Doctrine Command
USA	United States Army
Vulcan	Current U.S. track mounted anti-aircraft gun

ATTACHMENT 2  
ELECTROMAGNETIC PATH LOSS SURVEY FOR THE INTEGRATED BATTLEFIELD  
RESEARCH STUDY PROGRAM AT FT. IRWIN

1.0 INTRODUCTION

1.1 Purpose

A brief electromagnetic path loss survey was performed at Ft. Irwin on 27 October 1983 and 28 October 1983. The purpose of the test program was to measure RF path loss at 148 MHz and 410 MHz at selected receive sites. The data presented herein is complete and is intended to be representative of the anticipated path loss for all of Ft. Irwin for the two test frequencies. Due to the limited number of test receive sites, test transmit sites and test frequencies, the test program cannot be considered as an exhaustive study of the RF propagation characteristics at Ft. Irwin.

1.2 Scope

Details of the test program include:

Dates of test: 27 and 28 October 1983

Location: Ft. Irwin, CA

Test Frequencies: 148 MHz and 410 MHz

<u>Test Date</u>	<u>Transmit Site</u>	<u>Receive Site</u>
27 October 83	Tiefort Mountain (400 030)	(275 945)
27 October 83	Tiefort Mountain	(325 950)
27 October 83	Tiefort Mountain	(383 974)
27 October 83	Tiefort Mountain	(453 973)
27 October 83	Tiefort Mountain	(576 049)
27 October 83	Tiefort Mountain	(491 011)
27 October 83	Tiefort Mountain	(473 048)
27 October 83	Tiefort Mountain	(458 035)

<u>Test Date</u>	<u>Transmit Site</u>	<u>Receive Site</u>
28 October 83	Tiefort Mountain (400 030)	(320 112)
28 October 83	Tiefort Mountain	(270 128)
28 October 83	Tiefort Mountain	(260 142)
28 October 93	Tiefort Mountain	(448 269)
28 October 83	Tiefort Mountain	(468 280)
28 October 83	Tiefort Mountain	(526 256)
28 October 83	Granite Mountain (376 212)	(320 112)
28 October 83	Granite Mountain	(270 128)
28 October 83	Granite Mountain	(260 142)
28 October 83	Granite Mountain	(448 268)
28 October 83	Granite Mountain	(468 280)
28 October 83	Granite Mountain	(526 256)

This report documents the test results which are based on the foregoing details. In addition, an analysis has been performed to calculate RF path loss over a mountainous terrain. The calculated data is included herein and compared with the test data.

## 2.0 APPLICABLE DOCUMENTS

EW magazine	"Jamming Calculations for FM
November/December	Voice Communications" by
1976 issue	Lawrence E. Follis

## 3.0 TEST EQUIPMENT

### 3.1 Antennas

Transmit

(2)	T-1	Empire Devices	148 MHz
(1)	T-2	Empire Devices	148 MHz
			410 MHz
(1)	T-3	Empire Devices	410 MHz

Receive

(1)	BLA-25	Fairchild	148 MHz
(1)	LPD-2010/RA	Antenna	410 MHz
		Research Assoc.	

3.2 Receiver

NM-37/57	Stoddart	148 MHz, 410 MHz
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3.3 R.F. Sources

Model 5000	IFI 10 WATT Amplifier	148 MHz
(2) Model 445A	AILTECH	148 MHz, 410 MHz

3.4 Power Meters

Wattmeter	Bird	148 MHz, 410 MHz
HP-432A	Hewlett-Packard	148 MHz, 410 MHz
3000-20	Narda directional coupler	410 MHz

4.0 TEST SITES4.1 Transmit Sites

On Thursday 27 October 1983 the RF sources were taken by helicopter to the NASA site on Tiefort Mountain. The test engineers alternately transmitted on 148 MHz and 410 MHz.

On Friday 28 October 1983 the RF sources were taken by helicopter to both Tiefort Mountain and Granite Mountain. Table B-1 shows the transmit procedure developed to circumvent the loss of voice communications between the transmit sites and the mobile receive sites.

#### 4.2 Mobile Receive Sites

The various receive sites were selected in advance. Primary consideration was given to selecting receive sites that would most closely identify areas which result in the highest transmission losses. Open sites were also selected.

#### 4.3 Test Range Description

Receive sites were selected in the Live Fire Range, Central Corridor, and Southern Range. The terrain was very rough, hilly and the earth was composed primarily of sand. The nearby mountains were composed of various minerals such as iron, copper, silver, and gold. No man made obstacles were observed.

#### 5.0 TEST PROCEDURE

The RF sources were taken to the transmit sites by helicopter and configured in a test setup for one frequency. The time of day and power output were noted and recorded on the test data sheet.

The RF receiver and receive test team drove to the various receive sites in a 4-wheel drive Ford Bronco. Once positioned at a selected test site, the receive team would attempt to establish voice communications, via hand held radio, with the transmit site. If voice communications were possible, the transmit frequency could be verified, then the appropriate receive antenna

Table B-1. Transmit procedure used on 28 October 1983

Start transmitting at times indicated. Breakdown after about 8 minutes in time to start transmitting on the next frequency.

<u>GRANITE</u>		<u>TIEFORT</u>	
UHF	VHF	UHF	VHF
9:00	9:10	9:10	9:00
9:20	9:30	9:30	9:20
9:40	9:50	9:50	9:40
10:00	10:10	10:10	10:00
10:20	10:30	10:30	10:20
10:40	10:50	10:50	10:40
11:00	11:10	11:10	11:00
11:20	11:30	11:30	11:20
11:40	11:50	11:50	11:40
12:00	12:10	12:10	12:00
12:20	12:30	12:30	12:20
12:40	12:50	12:50	12:40
1:00	1:10	1:10	1:00
1:20	1:30	1:30	1:20
1:40	1:50	1:50	1:40
2:00	2:10	2:10	2:00
2:20	2:30	2:30	2:20
2:40	2:50	2:50	2:40
3:00	3:10	3:10	3:00
3:20	3:30	3:30	3:20
3:40	3:50	3:50	3:40
4:00	4:10	4:10	4:00
4:20	4:30	4:30	4:20
4:40	4:50	4:50	4:40
5:00	5:10	5:10	5:00

would be mounted on a tripod and connected to the RF input of the test receiver. The received frequency, amplitude, time of day and coordinates of the receive site were then recorded on the test data sheet. Radio communications were then established with the transmit site, at which time the transmit site was instructed to change frequencies. The receive test team changed antennas and recorded the receive parameters at the test frequency.

On Thursday, the test teams experienced considerable difficulty in maintaining communications at all of the receive sites. Several times it was necessary for two of the test team members to drive around in an army jeep until radio communications could be established with the transmit site. As a result, a procedure was developed for the transmit sites to change frequencies at predetermined times. The schedule, presented in Table 1 was then followed on Friday.

#### 6.0 TEST RESULTS

Details of the test results are presented in Figures 1 through 6. Most reliable transmission was experienced using 148 MHz. In total, there were 20 receive test sites. On Thursday, RF transmission was successful at 100% of the receive sites. On Friday, there were six receive sites. Transmission was successful five out of six sites or 83% of the sites at 148 MHz and 410 MHz with Granite Mountain. Transmission was successful 100% of the sites at 148 MHz with Tiefort and 67% of the sites at 410 MHz with Tiefort.

The electromagnetic environment was quiet and no interference was experienced. The receiver noise level was recorded at -119 dBm. Therefore the test setup had a dynamic range of 171 dB for test number 38 and 39 where transmission was not established.

**TEST DATE:** 10/27/83      **Transmit Antenna:** T-1  
**TEST FREQUENCY:** 148.2 MHz      **Receive Antenna:** BIA-25  
**TRANSMITTER LOCATION:** Tiefert (400 030)

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER			Measured path dB	Calculated path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>			
A 1	(275 945)	43.0	4.3	48.1	-100	-4.7	-103.3	-151.4	-160.5	15.3
B 2	(325 950)	43.0	4.3	48.1	-104	-4.7	-99.3	-147.4	-137.4	11.2
C 3	(303 974)	43.0	4.3	48.1	-72	-4.7	-67.3	-115.4	-133.2	6
D 4	(453 973)	44.2	4.3	48.5	-57	-4.7	-52.3	-100.0	-93.0	7.7
E 5	(576 049)	44.2	4.3	48.5	-112	-4.7	-107.3	-155.0	-161.3	17
F 6	(491 011)	44.0	4.3	49.1	-76	-4.7	-71.3	-120.4	-136	9.4
G 7	(473 040)	44.5	4.3	48.8	-87	-4.7	-82.3	-131.1	-134.3	7.4
H 8	(450 035)	44.8	4.3	49.1	-84	-4.7	-79.3	-128.4	-132.0	5.6

Figure B-1. Test data taken at 148 MHz on 27 October 1983

TEST DATE: 10/27/83  
 TEST FREQUENCY: 410 MHz  
 TRANSMITTER LOCATION: Tiefert (400 030)

Transmit Antenna: T-3  
 Receive Antenna: LPD-2010/BA

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER				Calculated path dB	Measured path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>				
A 9	(275 945)	39.5	4.3	41.9	-108	0	-116		-153.8	-157.9	15.3
B 10	(325 950)	39.8	4.3	41.9	-104	0	-112		-150.6	-156.1	11.2
C 11	(383 974)	40.6	4.3	44.9	-72	0	-80		-146.4	-124.9	6
D 12	(433 973)	40.6	4.3	44.9	-57	0	-65		-102.6	-109.9	7.9
E 13	(576 849)	40.6	4.3	44.9	-112	0	-120		-167.9	-164.9	17
F 14	(491 811)	41	4.3	45.3	-76	0	-84		-149.2	-129.3	9.4
G 15	(473 840)	41	4.3	45.3	-87	0	-95		-147.5	-140.3	7.4
M 16	(458 835)	41	4.3	45.3	-84	0	-92		-146	-137.3	5.6

Figure B-2. Test data taken at 410 MHz on 27 October 1983

**TEST DATE:** 10/28/83      **Transmit Antenna:** T-1  
**TEST FREQUENCY:** 148 MHz      **Receive Antenna:** BIA-25  
**TRANSMITTER LOCATION:** Granite Mountain (376 212)

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER			Measured path dB	Calculated path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>			
J 17	(320 112)	44.0	4.3	40.0	-119	-4.7	-114.3	-163.1	-150.6	11.5
K 18	(270 120)	44.0	4.3	49.1	- 89	-4.7	- 84.3	-133.4	-139.2	13.5
L 19	(260 142)	44.0	4.3	49.1	- 97	-4.7	- 92.3	-141.4	-139.3	13.6
M 20	(440 260)	44.0	4.3	49.1	-102	-4.7	- 97.3	-146.4	-135.7	9.1
N 21	(460 280)	44.0	4.3	49.1	-114	-4.7	-109.3	-150.4	-150.5	11.4
O 22	(526 256)	44.0	4.3	49.1	no detectable signal	-4.7	-0-	-0-	-150.7	15.6

Figure B-3. Test data taken at 148 MHz on 28 October 1983 from Granite Mountain

**TEST DATE:** 10/28/83      **Transmit Antenna:** T-3  
**TEST FREQUENCY:** 410 MHz      **Receive Antenna:** LPD-2010/RA  
**TRANSMITTER LOCATION:** Granite Mountain (376 212)

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER				Calculated path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Measured path dB		
J 23	(320 112)	46.02	4.3	50.3	- 56	0	- 64	-114.3	-105.9	11.5
K 24	(270 120)	45.9	4.3	50.2	- 74	0	- 82	-132.2	-152.4	13.5
L 25	(260 142)	45.7	4.3	50.0	-115	0	-123	-173	-166.3	13.6
M 26	(440 260)	45.2	4.3	49.5	-112	0	-120	-169.5	-164	9.1
N 27	(467 200)	45.6	4.3	49.9	-108	0	-116	-165.9	-165.2	11.4
O 28	(526 256)	45.2	4.3	49.5	no detect- able signal	0	-0-	-0-	-160.6	15.6

Figure B-4. Test data taken at 410 MHz on 28 October 1983 from Granite Mountain

TEST DATE: 10/28/83

Transmit Antenna: T-1

TEST FREQUENCY: 148 MHz

Receive Antenna: BIA-25

TRANSMITTER LOCATION: Tiefert (400 030)

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER				Calculated path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Measured path dB		
P 29	(320 112)	40	4.3	44.3	-113	-4.7	-108.3	-152.6	-158.6	11.5
R 30	(270 120)	40	4.3	44.3	-117	-4.7	-112.3	-156.6	-161	16.3
S 31	(260 142)	40	4.3	44.3	-117	-4.7	-112.3	-156.6	-161.7	17.9
T 32	(440 260)	40	4.3	44.3	-109	-4.7	-104.3	-148.6	-147.1	24.3
U 33	(460 280)	40	4.3	44.3	-119	-4.7	-114.3	-158.6	-165.5	25.9
V 34	(526 256)	40	4.3	44.3	-117	-4.7	-112.3	-156.6	-148.3	25.9

Figure B-5. Test data taken at 148 MHz on 18 October 1983 from Tiefert Mountain

**TEST DATE:** 10/28/83      **Transmit Antenna:** T-3  
**TEST FREQUENCY:** 410 MHz      **Receive Antenna:** LPD-2010/BA  
**TRANSMITTER LOCATION:** Tiefert (400 030)

TEST NUMBER	TEST SITE	TRANSMITTER			RECEIVER			Calculated path dB	Path distance km
		Antenna input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>	Received input power dBm	Antenna gain dB	Power density dBm/m <sup>2</sup>		
P 35	(320 112)	44	4.3	48.3	-94	0	-102	-150.3	11.5
R 36	(270 120)	44	4.3	48.3	-112	0	-120	-168.3	16.3
S 37	(260 142)	44	4.3	48.3	-104	0	-112	-168.3	17.9
T 38	(400 268)	44	4.3	48.3	no detectable signal	0	-0-	-165.9	24.3
U 39	(400 200)	44	4.3	48.3	no detectable signal	0	-0-	-166.0	25.9
V 40	(526 256)	44	4.3	48.3	-105	0	-113	-161.3	25.9

Figure B-6. Test data taken at 410 MHz on 18 October 1983 from Tiefert Mountain

Figures B-1 through B-6 also presents calculated path loss. The calculation was performed three different ways: a) line of sight (LOS) no obstacles, b) LOS with one obstacle and c) LOS with more than one obstacle. In several calculations, the conditions which produced the closest results between calculated and measured at 148 MHz did not agree with the same conditions at 410 MHz. In general there is good agreement between the calculations and the test results. A total of 40 calculations were performed, however no test data was collected at 4 test sites. In comparing the calculated data with the corresponding measured data 18 points agreed within 5 dB which corresponds to 50%. Thirty one of the calculated test points and measured test points agreed within 10 dB which corresponds to 86%.

## 7.0 SUMMARY

### 7.1 Conclusions

The greatest measured path loss at 410 MHz was 169.5 dB and 163.1 dB represents the greatest path loss at 148 MHz.

#### Assume:

RF receiver sensitivity	:	-120 dBm
10 dB S+N	:	<u>10 dB</u>
		-110 dBm
Receive Antenna Gain	:	<u>0 dB</u>
required receive signal	:	-110 dBm/m <sup>2</sup>
level		
worst case path loss	:	-170 dB

#### Resultant:

transmit power density	:	60 dBm/m <sup>2</sup>
transmit antenna gain	:	4.3 dB
required transmitter power	:	55.7 dBm
output		or 372 Watts

The test data shows that one transmitter located on Tiefort Mountain, operating at 148 MHz with a minimum output power density of  $60 \text{ dBm/m}^2$  can provide complete range coverage to a receiver which has a sensitivity of  $-120 \text{ dBm/m}^2$ .

## 7.2 Recommendations

The results show that a commercially available 500 Watt transmitter driving a dipole antenna will meet the desired transmission requirements.

1. Additional measurements should be performed to determine if a) 148 MHz represents the most efficient frequency and b) if the test results presented are truly representative of the propagation characteristics at Ft. Irwin.

2. A receiver, having the RF characteristics described herein, should be constructed. A transmitter, having the required transmission characteristics could operate from a preferred location on Tiefort Mountain. The receiver could then be taken throughout Ft. Irwin to verify transmission results.

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ATTN: C. Anderson  
ATTN: DASAC

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Science Applications International Corp

ATTN: B. Packard  
ATTN: D. Erickson  
ATTN: J. Birney  
ATTN: J. Ickler  
ATTN: J. Martin  
ATTN: L. Metzger  
ATTN: M. Drake  
ATTN: P. McKeown  
ATTN: P. Plock

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Kaman Tempo

ATTN: DASIAC